

CLAIMS

What is claimed is:

1        1.        A structure in an integrated circuit, said  
2        structure extending from a conductive surface through  
3        a channel having inner walls extending above said  
4        conductive surface, said structure comprising:

5                a layer of a refractory metal residing on said  
6        conductive surface and said inner walls of said  
7        channel; and

8                a layer of a metal nitride residing on said layer  
9        of said refractory metal, wherein said layer of said  
10      metal nitride has a thickness extending from said layer  
11      of said refractory metal of less than 130 Å.

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1        2.        The structure of claim 1, wherein said layer  
2        of said metal nitride has a thickness in the range of  
3        25 to 75 Å.

1        3.        The structure of claim 1, wherein said layer  
2        of said refractory metal and said layer of said metal  
3        nitride have a combined thickness extending from said  
4        inner walls of said channel of less than 200 Å.

1        4.        The structure of claim 1, wherein said  
2        structure has a width that is less than or equal to

3 3,000 Å.

1 5. The structure of claim 1, wherein a ratio of  
2 a height of said structure to a width of said structure  
3 is greater than or equal to 3.33.

1 6. The structure of claim 1, wherein said layer  
2 of said refractory metal has a thickness extending from  
3 said inner walls of said channel in a range of 25 to  
4 100 Å.

1 7. The structure of claim 1, wherein said  
2 refractory metal is a metal selected from the group  
3 consisting of titanium, tantalum, cobalt and  
4 molybdenum.

1 8. The structure of claim 1, wherein said metal  
2 nitride has a resistivity of less than 600  $\mu\Omega\text{-cm}$ .

1 9. The structure of claim 1, wherein said metal  
2 nitride includes a metal selected from the group  
3 consisting of titanium, zirconium, hafnium, tantalum,  
4 molybdenum and tungsten.

1 10. The structure of claim 1, further including:  
2 a layer of a metal residing on said layer of said

3 metal nitride.

1 11. The structure of claim 10 wherein said metal  
2 nitride is adhesive to said metal.

1 12. The structure of claim 10, wherein said metal  
2 is tungsten.

1 13. The structure of claim 10, wherein said  
2 structure has a resistance less than or equal to 3.0  $\Omega$ .

1 14. The structure of claim 13, wherein said  
2 channel has an aspect ratio grater than or equal to  
3 3.33.

1 15. A structure in an integrated circuit, said  
2 structure extending from a conductive surface  
3 surrounded by a channel having inner walls extending  
4 from said conductive surface, said structure  
5 comprising:

6 a layer of a refractory metal having a thickness in  
7 a range of about 25 to 100  $\text{\AA}$  residing on said  
8 conductive surface and said inner walls of said  
9 channel; and

10 a layer of a metal nitride residing on said layer  
11 of said refractory metal, wherein said layer of said

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12 metal nitride has a thickness extending from said layer  
13 of said refractory metal of less than 130 Å.

1 16. The structure of claim 15, wherein said layer  
2 of said metal nitride has a thickness in the range of  
3 25 to 75 Å.

1 17. The structure of claim 15, wherein said layer  
2 of said refractory metal and said layer of said metal  
3 nitride have a combined thickness extending from said  
4 inner walls of said channel of less than 175 Å.

1 18. The structure of claim 15, wherein said  
2 channel has an aspect ratio greater than or equal to  
3 3.33.

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1 19. The structure of claim 15, wherein said  
2 refractory metal is a metal selected from the group  
3 consisting of titanium, tantalum, cobalt, and  
4 molybdenum.

1 20. The structure of claim 15, wherein said metal  
2 nitride includes a metal selected from the group  
3 consisting of titanium, zirconium, hafnium, tantalum,  
4 molybdenum and tungsten.

1                   21. A method for forming a structure in an  
2 integrated circuit, said structure extending from a  
3 conductive surface through a channel having inner walls  
4 extending above said conductive surface, said method  
5 including the steps of:

6                   (a) depositing a layer of a refractory metal on  
7 said conductive surface and said inner walls of said  
8 channel; and

9                   (b) forming a layer of a metal nitride on said  
10 layer of said refractory metal, wherein said layer of  
11 said metal nitride has a thickness extending from said  
12 layer of said refractory metal of less than 130 Å.

1                   22. The method of claim 21, wherein said layer of  
2 said metal nitride has a thickness in the range of 25  
3 to 75 Å.

1                   23. The method of claim 21, wherein said layer of  
2 said refractory metal and said layer of said metal  
3 nitride have a combined thickness extending from said  
4 inner walls of said channel of less than 200 Å.

1                   24. The method of claim 21, wherein said step (b)  
2 includes the steps of:

3                   depositing said metal nitride on said layer of said  
4 refractory metal; and

5 plasma annealing said metal nitride.

*1*  
*2*  
*3*  
*4*  
*5*  
*6*  
*7*

25. The method of claim 24, wherein said step of plasma annealing includes the steps of:  
exposing said metal nitride to an environment containing ions; and electrically biasing said layer of said metal nitride to cause said ions from said environment to impact said metal nitride.

1 26. The method of claim 25, wherein said step of exposing said metal nitride to said environment containing ions includes the steps of:  
providing a gas; and providing a first rf signal to a first electrode on a first side of a wafer on which said structure is being formed to provide energy to said gas.

1 27. The method of claim 26, wherein said gas contains at least one gas selected from the group consisting of nitrogen, hydrogen, argon, helium, and ammonia.

1 28. The method of claim 26, wherein said metal nitride includes at least one material selected from the group consisting of titanium, tantalum, tungsten,

4 hafnium, molybdenum, and zirconium.

1 29. The method of claim 26, wherein said gas  
2 includes a noble gas.

1 29. The method of claim 24, wherein said step of  
2 depositing said metal nitride and said step of plasma  
3 annealing are both performed in a single chamber and  
4 without removing a wafer on which said structure is  
5 being formed from the chamber between beginning said  
6 step of depositing said metal nitride and completion of  
7 said step of plasma annealing.

*Mark 32*

1 31. The method of claim 24, wherein said step of  
2 depositing said metal nitride is performed using  
3 chemical vapor deposition.

1 32. The method of claim 24, wherein said step of  
2 plasma annealing includes the steps of:  
3 performing a first plasma annealing of said metal  
4 nitride; and  
5 performing a second plasma annealing of said metal  
6 nitride after performing said first plasma annealing.

1 33. The method of claim 32, wherein said step of  
2 performing said first plasma annealing includes the

3 steps of:

4 exposing said metal nitride to a first environment  
5 containing ions; and

6 electrically biasing said metal nitride to cause  
7 said ions from said first environment to impact said  
8 metal nitride.

1 34. The method of claim 33, wherein said step of  
2 performing said second plasma annealing includes the  
3 steps of:

4 exposing said metal nitride to a second environment  
5 containing ions; and

6 electrically biasing said metal nitride to cause  
7 said ions from said second environment to impact said  
8 layer of said metal nitride.

1 35. The method of claim 34, wherein said step of  
2 exposing said metal nitride to a first environment  
3 containing ions includes the steps of:

4 providing a first gas, and

5 providing energy to said first gas to generate a  
6 first plasma, and

7 wherein said step of exposing said metal nitride to  
8 a second environment containing ions includes the steps  
9 of:

10 providing a second gas, and

11       providing energy to said second gas to generate a  
12       second plasma.

1       36. The method of claim 35, wherein said first gas  
2       contains at least one gas selected from the group  
3       consisting of nitrogen, hydrogen, argon, helium, and  
4       ammonia.

1       37. The method of claim 35, wherein said second gas  
2       contains at least one gas selected from the group  
3       consisting of nitrogen, helium, neon, and argon.

1       38. The method of claim of claim 32, wherein said  
2       step of depositing said metal nitride is performed  
3       using chemical vapor deposition.

1       39. The method of claim 32, wherein said step of  
2       depositing said metal nitride and said step of plasma  
3       annealing are both performed in a chamber without  
4       removing a wafer on which said structure is being  
5       formed from the chamber between initiating said step of  
6       depositing said metal nitride and completing said step  
7       of plasma annealing.

1       40. The method of claim 21, wherein said channel  
2       has a width less than or equal to 3,000 Å.

1       41.   The method of claim 21, wherein said channel  
2   has an aspect ratio that is greater than or equal to  
3   3.33.

1       42.   The method of claim 21, wherein said  
2   refractory metal is deposited in said step (a) by  
3   physical vapor deposition.

1       43.   The method of claim 21, wherein said  
2   refractory metal is deposited in said step (a) by  
3   chemical vapor deposition.

1       44.   The method of claim 43, wherein said  
2   refractory metal is a metal selected from the group  
3   consisting of titanium, tantalum, cobalt, and  
4   molybdenum.

1       45.   The method of claim 21, further including the  
2   step following said step (b) of:

3       (c)   depositing a layer of a metal on said layer  
4   of said metal nitride.

1       46.   The method of claim 45, wherein said metal is  
2   tungsten.

1       47. The method of claim 46, further including the  
2 step following said step (c) of:

3       (d) etching said layer of said refractory metal,  
4 said layer of said metal nitride, and said layer of  
5 said metal to decompose portions of said layer of said  
6 refractory metal, said layer of said metal nitride, and  
7 said layer of said metal that reside outside of said  
8 channel.

1       48. A method for forming a barrier layer over a  
2 conductive surface surrounded by a channel having inner  
3 walls extending above said conductive surface, said  
4 method including the steps of:

5       (a) depositing a layer of a refractory metal on  
6 said conductive surface and said inner walls of said  
7 channel to a thickness in a range of about 25 to 100 Å;

8       (b) depositing a layer of a metal nitride on said  
9 layer of said refractory metal; and

10      (c) plasma annealing said layer of said metal  
11 nitride, wherein said layer of said metal nitride has  
12 a thickness extending from said layer of said  
13 refractory metal of less than 130 Å after completing  
14 said step (c).

1       49. The method of claim 48, wherein said step (c)  
2 includes the steps of:

3           providing a gas;  
4           providing energy to said gas to generate an  
5        environment containing ions; and  
6           electrically biasing said metal nitride to cause  
7        said ions from said environment to impact said metal  
8        nitride.

1        50.    The method of claim 49, wherein said metal  
2        nitride includes at least one material selected from  
3        the group consisting of titanium, tantalum, tungsten,  
4        hafnium, molybdenum, and zirconium.

1        51.    The method of claim 48, wherein said step (c)  
2        includes the steps of:  
3           performing a first plasma annealing of said metal  
4        nitride; and  
5           performing a second plasma annealing of said metal  
6        nitride after performing said first plasma annealing.

1        52.    The method of claim 48, wherein said channel  
2        has a width less than or equal to 3,000 Å.

1        53.    The method of claim 52, wherein said channel  
2        has an aspect ratio that is greater than or equal to  
3        3.33.